The Zonal Distribution of Three Species of Staphylinidae in the Rocky Intertidal Zone in California
(Coleoptera : Staphylinidae)

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The Staphylinidae of the intertidal zone on rocky shores have received sporadic attention for the last 100 years. Mäklin (1853), Le Conte (1861), and Casey (1885), were concerned with identification, while Chamberlin and Ferris (1929), Moore (1956a, b), Usinger (1956), and Glynn (1965), included notes regarding their natural history and distribution. A review of the available literature indicates that no work has been done on the distribution of the rocky intertidal Staphylinidae.

This paper attempts to define, within a selected study area, the distribution of three local species of rocky intertidal staphylinids: *Liparocephalus cordicollis,* Le Conte; *Diaulota vandykei,* Moore; and *Diaulota densissima,* Casey. The work was done at Hopkins Marine Station, Pacific Grove, California over a period of ten weeks from 19 June through 27 August 1967. Field studies were carried out at a site located on Point Pinos immediately south of the Great Tidepool (36 38′ N; 121 56′ W).

Description of the Study Area

The study area is representative of the Monterey Peninsula rocky intertidal. Point Pinos is a rocky reef projecting into the Pacific Ocean. Off-shore rocks tend to break the force of the waves and protect the shore line.

The site was 50 feet wide and 121 feet long. The very gradual slope had no depressions greater than 2 feet and contained one mass of boulders 5 feet high located centrally in lower zone II. There is a vertical drop of 7.8– feet from the high water mark of 6.4– feet on the boulder-beach to the low water mark of –1.4– feet (the highest and lowest tides during the study).

Boulders up to 8 feet long and 3 feet wide are scattered about in zones III and IV; these are mixed with a much larger number of smaller rounded boulders and projecting rocks. In zones I and II the rocks range from 3 feet down to several inches in diameter.

A prolific growth of mixed algae covering zones III and IV, thins out in zone II and disappears in zone I, leaving the rocks bare on the boulder-beach.

High rock masses, 5 to 8 feet, form broken shoulder boundaries along the sides of the selected site. Scattered *Mytilus-Pollicipes* communities along with patches of *Pelvetiopsis* and *Cladophora* dot these rocks on their seaward extremities.

The system of zonation applied is that of Ricketts and Calvin (1962). The distribution of the staphylinids was worked out according to the tide levels at which they occurred and the zones then assigned.

The zonation of the intertidal algae has been established by Smith (1951). They are relatively fixed, and form reliable "markers." Thirty-one species were used in this study to determine the distribution of the three staphylinids with which they are associated. The vertical range of each of the 31 most common algal species in the study area was checked against that given by Smith (1951). These were then checked against the tidal range measured at the site and that given in local Tide Tables. For the purpose of this study, only minor variations were found due to local conditions at the site. The algal ranges of 9 of the 31 species used, as determined at the study site, are shown in Figure 1.

Certain algal species provide protection, air spaces, and direct and indirect supplies of food. To this extent their distribution and that of the staphylinids coincide. However, no attempt is being made here to establish or prove any direct relationship between any algal species and the staphylinids. The algae have been used as a source of beetles, and as "markers," since their distribution has already been established.

Sampling Program

Depending upon the tide, the area was visited on an average of once each day. Collections were made along the water's edge or at specific distances with respect to it, usually above—but sometimes samples were taken below the surface. The most characteristic algae of the study area were collected and identified.

The exact location of each algal sample was fixed by references to the tide level at the time it was collected, by checking its position against previously established tide level markers on the boulders, and by reference to its distribution as given in Smith (1951).

Method of Sampling

Three sampling methods were used. The aim was to establish the general pattern of distribution of the 3 staphylinids within the rocky intertidal, not to indicate population density.

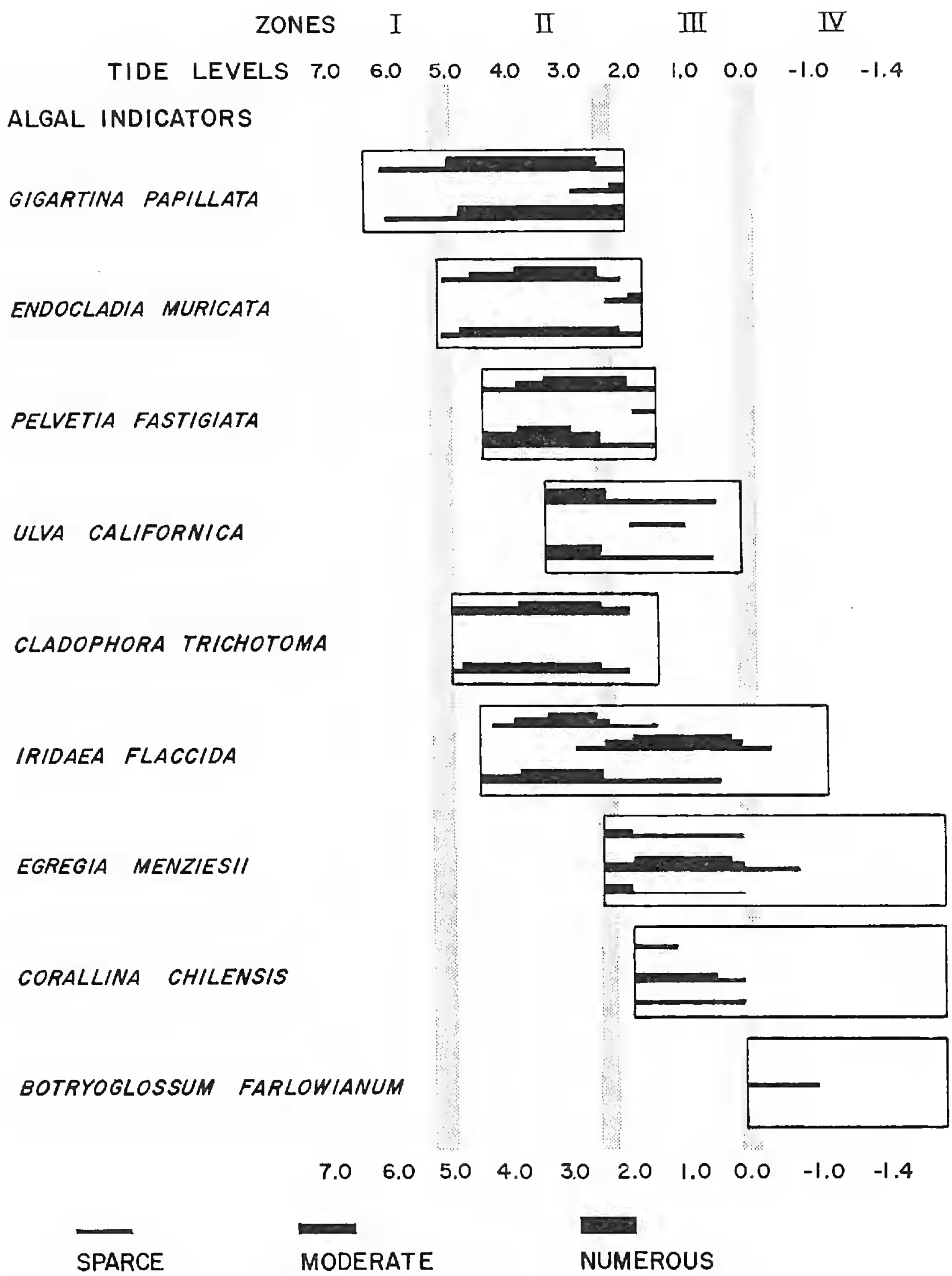

FIG. 1. Distribution and relative density of three rocky intertidal Staphylinidae plotted on the ranges of 9 selected algal species. Upper bar, *Diaulota densissima*; middle, *Liparocephalus cordicollis*; lower, *Diaulota vandykei.*

The first method consisted of visual examination of the rock surfaces. Observed specimens were preserved in alcohol and their location recorded. This proved to be slow, laborious, and inefficient. In zone IV there was not enough time for such a technique.

The second method consisted of splitting boulders with a crowbar and examining crevices for specimens. This also required time and great effort. Compensation was forthcoming, sometimes, in the form of one or two specimens. Also, many inhabitated crevices cannot be opened.

The third method, and the one that formed the basis of this work, consisted of collecting algal samples by scraping the rock surface. The material was placed in 4 × 5″ plastic bags for transport to the laboratory.

In the laboratory, each sample was placed on a hardware cloth screen in a 10″ diameter funnel under a 200-watt bulb. Motile organisms moved downward to escape the light and heat and were collected in vials of alcohol. This modified Berlese Funnel will collect all motile specimens in a sample including those far too minute to be seen in the field, even with a hand lens.

At the end of 24 hours all specimens were removed, identified, counted, recorded, and stored in 70% alcohol. Notes were kept in the field and in the laboratory on each sample with respect to species of algae, exact location, tide level, and exposure. To these data were added the numbers of each staphylinid species and associates recovered from the Berlese Funnels. An over-all summary of this information is shown in Figure 1.

Identification of Species

Samples were taken of 31 algal species within the study area. These were identified in the laboratory using Smith (1951), and Hollenberg and Abbott (1966). The identifications were checked by Dr. I. D. Abbott. Samples were preserved after identification for reference purposes.

The 3 species of staphylinids involved in this study were identified by use of the following keys and accompanying diagrams: Moore (1956a, b), Chamberlin and Ferris (1928), Saunders (1928), Usinger (1956), and Light, *et al.* (1961).

Moore's key and figures were used in the identification of adults. Chamberlin and Ferris produced the best illustrations available of larval urogomphi. Without the illustrations of the urogomphi, identification of the larvae would have been extremely difficult, if not impossible.

Sample specimens representative of the staphylinid adults and larvae were checked by Dr. W. G. Evans, University of Alberta, and Mr. Ian Moore, San Diego Museum of Natural History.

Zonal Distribution of Liparocephalus cordicollis

Specimens of *Liparocephalus cordicollis* were collected in zones II, III, and IV. Zone III apparently offers the most desirable habitat, as

TABLE 1. Summary of intertidal staphylinids collected and tabulated by zone and sampling technique.

Zones	*L. cordicollis* Adults	*L. cordicollis* Larvae	*D. densissima* Adults	*D. densissima* Larvae	*D. vandykei* Adults	*D. vandykei* Larvae	Total Coll.
I							
Algae	0	0	0	0	0	0	0
Surface	0	0	0	0	0	0	23
Crevice	0	0	0	2	8	4	56
II							
Algae	2	1	231	208	2	219	31
Surface	3	0	0	0	0	0	17
Crevice	0	5	16	5	11	9	36
III							
Algae	6	101	36	95	9	94	69
Surface	48	13	3	6	7	1	32
Crevice	1	17	2	3	12	5	27
IV							
Algae	0	5	0	1	0	0	68
Surface	0	0	0	0	0	0	35
Crevice	0	0	0	0	0	0	26
Total	60	142	288	320	49	332	420

indicated by the numbers of larvae and adults taken there. A sharp fall-off in numbers occurs at the 2.5– and 0.0– foot tide levels (Table 1). Moore (1956b: 212) reports *Liparocephalus* in the area of high tides 5.0– to 6.0– level.

The difference in numbers of *Liparocephalus cordicollis* adults and larvae collected in zone III (Table 1), is probably due in part to differing habitat preferences and to the method of sample collection. The larvae tend to prefer algal holdfasts; 21 were taken from one *Egregia* holdfast and 16 from another. The adults, when the tide goes out, seem to prefer darker open rock surfaces under algal thalli such as *Iridaea flaccida.* As the rocks dry off adults can be seen walking about in such areas. This habit of the adults of moving out onto the bare rock area would cause them to be missed more frequently in algal samples than the larvae.

The sharp decline in numbers in zone II remains unexplained. Although algal and rock crevices exist and humidity seems to remain high, in zone II algal cover is not as dense as that in zone III and, perhaps more important, zone II is exposed to drying for far longer periods of time than zone III. See Ricketts and Calvin (1962: 369) on critical exposure at the 3.5– foot level.

In this connection it may be of interest to note the drop in numbers between zone III and IV. *Liparocephalus cordicollis* does not seem to invade zone IV to any extent. However, they frequently can be seen moving down into zone IV from zone III as the tide moves out.

Five larval specimens of *Liparocephalus cordicollis*; 4 from *Botryoglossum* and 1 from an *Egregia* holdfast were collected in upper zone IV. Except for these 5 larval specimens, *Liparocephalus cordicollis* was not found in algal samples, split rocks, or surface examinations in zone IV when the rock was entirely confined within the limits of the zone. However, if the rock is high enough to extend up into zone III vertically, then specimens can be collected that have moved down as the tide receded. Saunders (1928: 544) notes that *Liparocephalus* and *Diaulota* are never found at the lowest tide levels which are only exposed a few days every month.

Zonal Distribution of Diaulota densissima

This species seems to be most concentrated in zone II with a decline in zone III and virtual absence in zones I and IV. Only 2 specimens were recovered from damp crevices above the 5-foot level where algal growth is reduced to fragments growing in protected depressions and along the outer margins of such crevices. The 2 specimens were the results of 56 split-rock and 23 surface examinations between the 5.0– and 7.0– foot tide levels. The indication is that the *Diaulota densissima* population density falls off sharply where algal growth is reduced or absent in zone I. Glynn (1965: 125) reports *Diaulota densissima* present at mid and high tide levels in his study of the *Endocladia-Balanus* community.

One *Diaulota densissima* larva was recovered below the 0.0– foot level on *Phyllospadix*. The sample came from a protected area surrounded by low algal-covered boulders. Additional samples of *Phyllospadix* and near-by algae failed to produce any more specimens. It could have been a "stray" washed out by wave action.

Adults and larvae were present in about equal numbers in zone II.

In zone III, the discrepancy in numbers of adults and larvae remains unexplained. The larvae are the more active and voracious feeders. They probably range farther afield and as a result are picked up in the algal samples more frequently.

Zonal Distribution of Diaulota vandykei

Diaulota vandykei was most numerous in zone II and III between 5.0– and 0.0– foot tide levels. Due to the virtual absence of algae in zone I, sampling at that level was done by examining the surface of 23 rocks and splitting a total of 56. From these crevices 12 specimens of *Diaulota vandykei* were recovered compared to 2 *Diaulota densissima.* If the difference in numbers between the 2 species is significant the explanation is not apparent.

Twice as many adults were taken in zone III, 2.5– to 0.0– foot tide levels, as in zone II, the 5.0– to 2.5– foot tide levels. From the same series of samples over 300 *Diaulota vandykei* larvae were collected in zone II and 100 in zone III. These figures appear to be indicative of actual differences or preferences on the part of the adults and larvae for a particular zone.

The figures in Table 1 indicate that the larvae of *Diaulota vandykei* are much more numerous during June, July, and August than are the adults. This may be a seasonal characteristic related to the life cycle which has not yet been worked out.

Ulva californica grows well at the zone II level and it traps considerable debris among the holdfasts. The larvae are found in the trapped debris.

Summary

(1) The main purpose of this study is to describe the zonal distribution of the following three species of rocky intertidal staphylinids: *Liparocephalus cordicollis, Diaulota densissima,* and *Diaulota vandykei,* within a selected "typical" and limited area of the Monterey Peninsula at Pacific Grove, California.

(2) The area studied was classified according to the 4 zones of Ricketts and Calvin (1962).

(3) The distribution of the three rocky intertidal staphylinids was determined by collecting algal samples within each zone, with the exception of zone I, and running them through a Berlese Funnel. In zone I where algal growth was too sparse to obtain samples by that method, the rocks were split and rock surfaces examined. Rocks were also split and rock surfaces examined in the other three zones in order to check the efficiency of the algal sampling technique.

(4) *Liparocephalus cordicollis* was most abundant in zone III with a total of 186 specimens, 5 were taken in zone IV, and 11 in zone II.

Diaulota densissima was found primarily in zones II and III, with only 1 specimen in zone IV and 2 in zone I.

Diaulota vandykei larvae were taken in relatively larger numbers than adults in zones II and III. No specimens were found in zone IV and 12 were collected in zone I.

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